Regions of Operation/Biasing

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STUDY FOR FE

Active Region (Amplification)

Condition # 1: B-E junction is FB

$V_{be} = 0.7V, i_c = \beta i_b = I_s e^{\frac{V_{BE}}{V_T}}$

Condition # 2: B-C junction is RB

$V_{bc} < 0$ OR $V_{ce} > 0.7V$
$V_{ce} = V_{cb} + V_{be} > 0.7V$
$\rightarrow V_{cb} + 0.7 > 0.7V$
$\rightarrow V_{cb} > 0V$
$\rightarrow V_{bc} < 0V$

Therefore, if V_{ce} is FB, V_{bc} will be RB

Summary

$V_{be} = 0.7V, i_c = \beta i_b$
$V_{bc} < 0$ OR $V_{ce} > 0.7V$

Saturation Region – (Switch ON)

Condition # 1: B-E junction is FB

$V_{be} = 0.7V, i_c = I_s e^{\frac{V_{BE}}{V_T}} \left(1 - \frac{e^{-\frac{V_{CE}}{V_T}}}{\alpha_{sat}}\right)$

Condition # 2: B-C junction is FB

$V_{bc} > 0$ OR $V_{ce} < 0.7V$
$V_{ce} = V_{cb} + V_{be} < 0.7V$
$\rightarrow V_{cb} + 0.7 < 0.7V$
$\rightarrow V_{cb} < 0V$
$\rightarrow V_{bc} > 0V$

Summary

$V_{be} = 0.7V$
$V_{ce} < 0.7V$
$V_{ce} \cong V_{ce-sat} = 0.2V$
$i_c < \beta i_b$

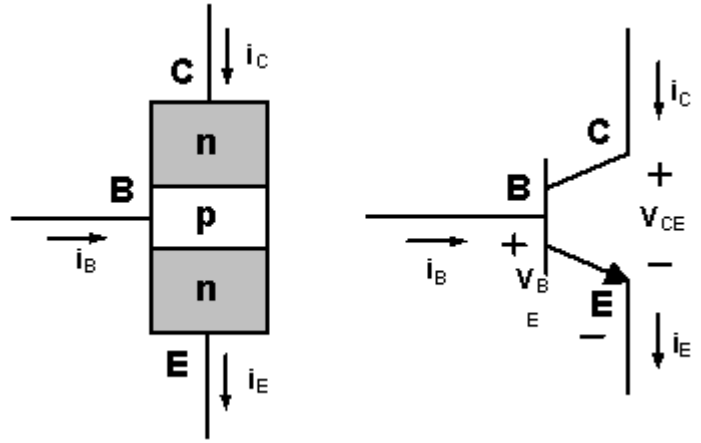
Cut-off Region – (Switch OFF)

Condition # 1: B-E junction is RB

$V_{be} < 0$
$i_b = i_c = i_e = 0$

Condition # 2: B-C junction is RB

$V_{bc} < 0$



Please review this specific portion of the on-demand lecture.
NCEES® FE Handbook doesn't provide this breakdown.

DC Circuit Analysis

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STUDY FOR FE

1. Assume an operating mode i.e. active, saturation or cut-off. Remember amplification happens in active region.

   Typically it is recommended to begin by active region unless you can observe otherwise.
2. Enforce the **equality conditions** relevant to region of operation.
3. Analyse the circuit with enforced conditions to calculate unknown currents/voltages.
4. Check the inequality conditions and compare results with assumptions. If they are consistent, you are done.
5. Otherwise, repeat the process by assuming different region of operation.

Active Region

Equality Conditions

$V_{be} = 0.7V, i_c = \beta i_b$

Inequality Conditions

$V_{bc} < 0$ OR $V_{ce} > 0.7V$

Saturation Region

Equality Conditions

$V_{be} = 0.7V, V_{ce} \cong V_{ce-sat} = 0.2V$

Inequality Conditions

$V_{ce} < 0.7V$

$i_c < \beta i_b$

Cutoff Region

Equality Conditions

$i_b = i_c = i_e = 0$

Inequality Conditions

$V_{be} < 0\ , V_{bc} < 0$